

AIR MINISTRY

METEOROLOGICAL OFFICE

FREQUENCY OF GROUND FROST IN SOUTH-WEST ENGLAND ON RADIATION NIGHTS.

By W. H. Hogg, M.Sc.

In this country, a ground frost is defined as a grass minimum temperature of 30.4°F. or less. Plants are not usually damaged until the surrounding air falls to this temperature, and often they are not damaged until the temperature falls considerably below this.

Screen minimum temperature can be forecast in a number of ways, and summaries of methods used have been published by Seltzer¹ and Kessler and Kaempfert². This investigation is concerned with the relation between screen minima and grass minima at 7 stations in south-west England. In particular, it has the following objects :-

- (i) To assess the chance of ground frost, given the screen minimum.
- (ii) To estimate the difference which may be expected between screen and grass minima.

A similar investigation for Australia was made by Foley³ who constructed correlation tables for all the grass minima of 30°F. or less and the corresponding screen minima.

The following stations have been used in the present investigation: Parkend, Cheltenham, Whitchurch, Porton, Cullompton, Tavistock and Ellbridge. Their positions are shown in Fig.1 and notes on their sites are given in Table I. The investigation has been confined to radiation nights on which the following weather prevailed from about dusk to dawn:-

- (i) Wind not greater than Beaufort force 2.
- (ii) Not more than 5 tenths low cloud.
- (iii) No precipitation.

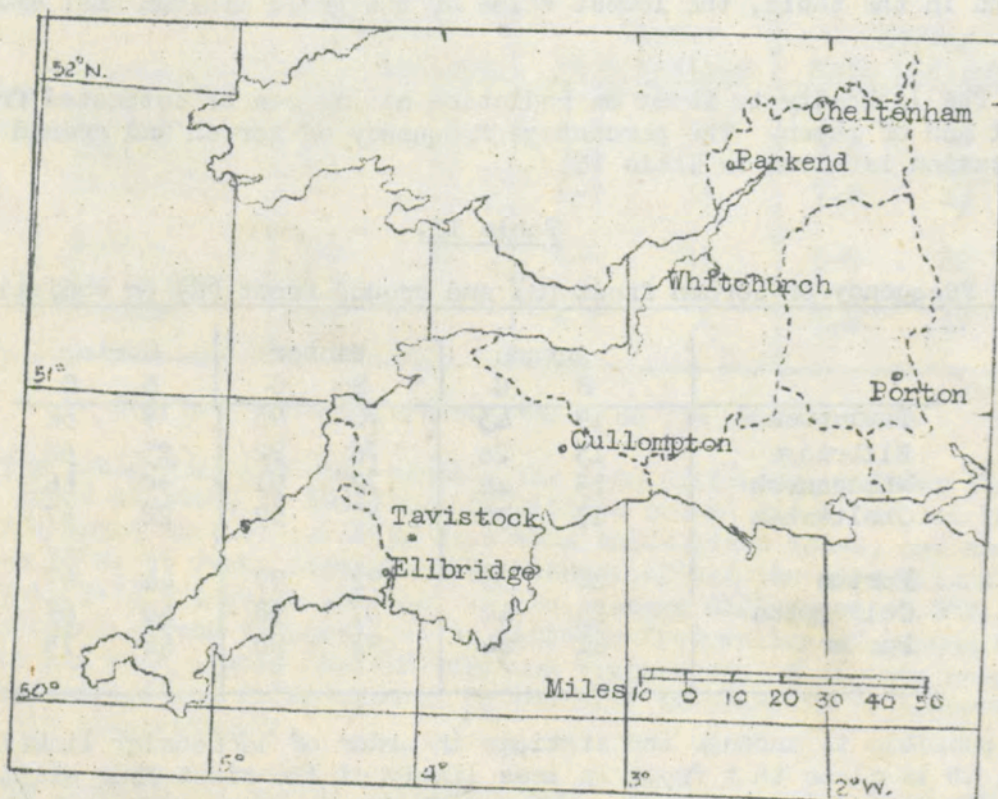


FIG.1. - SOUTH-WEST ENGLAND

* These numbers refer to the list of references on p.4.

Using this definition, the dates of radiation nights in the Midlands and south-west England (Districts 3, 4 and 5) have been found from the British Daily Weather Report (December 1937 - November 1947). Sometimes a radiation night occurred over only part of south-west England, and the frequency of radiation nights is therefore not the same at the 7 stations used. The general frequencies in the 10 years are :-

Autumn (Sept.-Nov.)	Winter (Dec.-Feb.)	Spring (Mar.-May)
234	143	289

In winter, only about 1 night in 6 or 7 is a radiation night compared with 1 in 3 in spring and 1 in 4 in autumn. The smaller number in winter is due mainly, but not entirely, to the cloudier nights which occur then.

For radiation nights, the screen and grass minima have been compared for the seven stations. These comparisons are summarised in Table I, which contains the following information:-

- (i) Number of radiation nights used.
- (ii) The frequency of all screen minima at or below which a ground frost was recorded during the period. Thus, as the autumn table for Ellbridge starts at 39°F. there were no ground frosts on radiation nights when the screen temperature was 40°F. or more. It is, of course, very unlikely that there were any ground frosts on non-radiation nights when the temperature was as high as this.
- (iii) The frequency of ground frosts for each screen minimum and the corresponding probability.
- (iv) The mean value of the grass minimum for each screen minimum on nights with ground frost. Mean values are given only when there are at least 4 occasions of ground frost.
- (v) The lowest value of the grass minimum corresponding to each screen minimum. It follows from (ii) that, for all screen minima exceeding the highest value given in the table, the lowest value of the grass minimum must exceed 30°F.

The liability to frost on radiation nights can be estimated from Table I (at end of paper). The percentage frequency of screen and ground frost at each station is given in Table II.

Table II.

Percentage frequency of screen frost (S) and ground frost (G) on radiation nights

	Autumn		Winter		Spring	
	S	G	S	G	S	G
Tavistock	19	43	70	95	19	58
Ellbridge	13	26	76	92	25	52
Whitchurch	15	44	77	91	30	66
Cheltenham	17	30	86	99	28	57
Porton	20	35	92	97	44	67
Cullampton	25	42	87	98	40	63
Parker	21	44	92	98	46	73

It is not possible to arrange the stations in order of increasing liability to frost, but it is clear that frost is less likely at the first four stations in Table II than at the other three. A glance at Fig.1. shows that this division is probably the result of local topography rather than the geographical position of the stations. In winter, a ground frost occurs on almost every radiation night.

The values of percentage frequency of ground frost in Table I can be used to determine the screen minima at (and below) which the probability of ground frost is at least 25, 50, 75, or is 100 per cent. The percentage frequencies given in Table I have been smoothed by using the formula $(a + 2b + c)/4$ and the screen minimum estimated for frequencies of 25, 50, 75 and 100 per cent. ground frost. The results are given in Table III.

Table III

Screen minimum temperatures at which the probability of ground frost is $\geq 25, 50, 75, 100$ per cent. on radiation nights

	Autumn				Winter				Spring			
	≥ 25	≥ 50	≥ 75	100	≥ 25	≥ 50	≥ 75	100	≥ 25	≥ 50	≥ 75	100
Tavistock	41	39	35	32	-	-	-	32	41	39	36	31
Ellbridge	38	35	34	33	-	-	36	32	40	38	36	32
Whitchurch	40	39	37	36	-	37	36	31	-	39	37	34
Cheltenham	37	36	35	32	-	-	-	39	39	37	36	33
Porton	37	34	33	33	-	-	-	35	38	37	36	33
Cullompton	37	36	35	34	-	-	-	35	38	37	36	33
Parkend	39	35	33	32	-	-	-	37	40	38	36	31

There are no consistent differences between the two groups of stations, but there is a tendency for the spring minima for 25, 50 and 75 per cent. at any station to be somewhat higher than the corresponding autumn value. This implies a somewhat greater frost risk in spring than in autumn for the same screen minimum.

The differences between the screen minima and corresponding mean grass minima (Table I) have been smoothed by $(a + 2b + c)/4$, and rough limits of these smoothed values for each station are given in Table IV which also contains the maximum difference recorded between the screen minimum and grass minimum on any radiation night.

Table IV

Mean and maximum difference between screen minimum and grass minimum (degrees Fahrenheit)

	Autumn		Winter		Spring	
	Mean	Maximum	Mean	Maximum	Mean	Maximum
Tavistock	7-8	20	8-10	21	9-10	20
Ellbridge	(6)	10	6-8	15	(7)	15
Whitchurch	8-9	13	7-8	15	8-9	15
Cheltenham	6-7	11	6-7	13	7-8	15
Porton	5-6	12	4-6	11	5-6	12
Cullompton	6-7	13	6-8	15	6-7	16
Parkend	6-7	16	6-7	16	7-8	17

The bracketed values are based on few observations

The table does not give exactly the mean difference between the screen minimum and grass minimum, as those nights without ground frost are not included. The mean differences must be slightly less than those given above, and can be taken as less than 10°F. at every station. The average of all the mean values given in Table IV is $7-7\frac{1}{2}^{\circ}\text{F.}$, which is close to the average difference of 8°F. adopted by Foley in using screen temperatures to estimate frequencies of ground frost. For India, it has been stated that the minimum temperature of objects near the ground, like crops on a field fully exposed to the sky, is about 10°F. lower than the minimum air temperature⁴.

The maximum difference between screen and grass minimum was 21°F. at Tavistock in winter, on a night when the screen minimum was down to 18°F. In spring and autumn there were differences of 20°F. at Tavistock on nights when the screen minimum fell to 40° and 49°F. respectively. Thus for this part of the country any

estimate of the probability of ground frost based on a correctly forecast screen minimum would almost always be on the safe side if a difference of 20°F. between screen and grass minimum temperatures was assumed.

Acknowledgement is made to the staff of the Agricultural Meteorology Branch who carried out the computation, and also to the Climatological Branch who supplied the daily observations on which the investigation is based.

Agricultural Meteorology Branch,
Meteorological Office

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References

1. SELTZER, P.; Études micrométéorologiques en Alsace. Annu. Inst. Phys. Globe, Strasbourg, Ann. 1934, 1^{ère} Partie: Météorologie, 1935, p.93.
2. KESSLER, O.W. and KÄMPFERT, W.; Die Frostscha-denverhütung. Wiss. Abh. Reichs. Wetterd., Berlin, 6, 1940, No.2.
3. FOLEY, J.C.; Frost in the Australian region. Bull. Bur. Met. Aust., Melbourne, No.32, 1945.
4. Poona, India Meteorological Department. Weather and the Indian farmer. Delhi, 1946.

Table I

Relation between screen minimum and grass minimum temperatures on radiation nights.

Winter 1937-8 to Autumn 1947

TAVISTOCK

Screen minimum	Autumn (Sept.-Nov.)* 223 radiation nights					Winter (Dec.-Feb.) 133 radiation nights					Spring (Mar.-May) 275 radiation nights				
	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum
°F.			%	°F.	°F.				°F.	°F.			%	°F.	°F.
49	9	1	11		29										
48	10	0	0												
47	7	0	0												
46	6	0	0												
45	9	0	0												
44	8	0	0								8	1	13		29
43	14	3	21		28						10	2	20		28
42	6	1	17		30						15	2	13		29
41	16	6	37	29	29						10	2	20		27
40	7	3	43		28						15	5	33	28	25
											10	5	50	26	20
39	9	5	55	28	27						16	10	63	28	26
38	16	10	63	29	27	1	1	100		29	20	13	65	28	25
37	15	8	62	28	22	7	6	86	26	20	15	11	73	27	23
36	2	1	50		26	6	6	100	27	23	16	14	87	26	22
35	5	5	100	28	25	7	7	100	25	23	16	11	69	24	20
34	5	5	100	26	23	7	7	100	26	23	16	16	100	26	18
33	7	6	86	26	23	9	7	78	25	17	19	18	95	24	20
32	8	8	100	24	19	9	9	100	25	21	6	5	83	26	22
31	3	3	100		23	15	15	100	23	15	13	13	100	20	17
30	8	8	100	25	20	4	4	100	22	18	6	6	100	22	15
29	7	7	100	21	17	13	13	100	21	11	8	8	100	20	15
28	5	5	100	19	17	5	5	100	19	17	5	5	100	19	16
27	3	3	100		16	9	9	100	17	14	5	5	100	15	14
26	4	4	100	17	16	6	6	100	15	13	2	2	100		14
25	2	2	100		23	9	9	100	16	11	1	1	100		18
24	1	1	100		16	5	5	100	13	10	2	2	100		10
23	1	1	100		14	6	6	100	16	14	0				
22	1	1	100		20	3	3	100		7	0				
21						2	2	100		10	0				
20						0					2	2	100		11
											0				
19						0									
18						2	2	100		-3	1	1	100		10
17						1	1	100		9					
16						1	1	100		3					
15						1	1	100		9					
<15						2	2	100		9					

*1937-46.

Site. - At a height of 475 ft. in open country near the top of a valley flank which slopes steeply down to the south-east, about 125 ft. above the valley floor. Clay soil.

Table I - continued.

ELLBRIDGE

Screen Minimum	Autumn (Sept.-Nov.) 227 radiation nights.					Winter (Dec.-Feb.) 132 radiation nights.					Spring (Mar.-May.) 277 radiation nights.				
	Frequency	Ground frost Frequency	Percentage Frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost Frequency	Percentage Frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost Frequency	Percentage Frequency	Mean grass minimum	Lowest grass minimum
°F.			%	°F.	°F.			%	°F.	°F.			%	°F.	°F.
44						2	1	50		29	15	1	7		30
43						0					16	1	6		30
42						1	0	0			10	2	20		29
41						0					8	1	13		28
40						0					14	6	43	29	28
39	16	1	6		30	0					13	6	46	28	27
38	14	4	29	29	28	2	0	0			11	6	55	28	25
37	12	6	50	29	27	7	5	71	28	28	18	10	56	27	23
36	3	1	33		26	3	2	67		28	11	9	82	29	25
35	7	5	71	28	26	6	6	100	28	23	17	15	88	28	22
34	5	3	60		27	5	4	80	28	26	11	10	91	28	26
33	9	9	100	28	25	5	4	80	26	26	11	9	82	26	22
32	11	11	100	27	23	10	10	100	26	22	16	16	100	27	23
31	3	3	100		21	13	13	100	26	20	6	6	100	25	20
30	4	4	100	23	22	16	16	100	23	17	15	15	100	23	19
29	3	3	100		24	11	11	100	23	18	13	13	100	22	18
28	1	1	100		25	4	4	100	21	17	8	8	100	21	13
27	3	3	100		21	9	9	100	18	13	2	2	100		19
26	1	1	100		18	7	7	100	18	17	2	2	100		16
25	1	1	100		21	7	7	100	19	17	3	3	100		18
24	2	2	100		18	5	5	100	17	15	1	1	100		16
23						4	4	100	18	16	1	1	100		20
22						4	4	100	15	12	0				
21						2	2	100		14	0				
20						0					0				
19						1	1	100		13	1	1	100		18
18						2	2	100		14					
17						0									
16						1	1	100		9					
15						0									
<15						3	3	100		7					

Site. - At a height of 200 ft. in open country on a moderate slope some 75-100 ft. above the valley bottom; the drainage of the cold air is liable to be impeded by an obstacle some 240 ft. down-slope from the station. Medium loam soil with clay in valley bottom.

Table I - continued

WHITCHURCH

Screen minimum °F.	Autumn (Sept.-Nov.) 234 radiation nights					Winter (Dec.-Feb.) 139 radiation nights					Spring (Mar. - May) 286 radiation nights				
	Frequency	Ground Frost frequency	Percentage Frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum
			%	°F.	°F.			%	°F.	°F.			%	°F.	°F.
43	18	1	6		30										
42	13	1	8		30										
41	13	1	8		30										
40	9	4	44	29	29						9	3	33		27
											11	0	0		
											14	3	21		30
39	17	10	59	29	26	4	2	50		29					
38	13	8	62	28	26	3	1	33		27	14	7	50	28	27
37	14	13	93	28	24	3	1	33		29	17	13	76	28	24
36	6	6	100	29	28	4	4	100	28	27	7	5	72	26	23
35	15	15	100	26	22	6	5	83	27	25	19	17	89	27	23
34	5	5	100	25	21	5	4	80	26	22	26	23	88	27	23
33	4	4	100	23	21	4	4	100	23	19	15	15	100	25	20
32	3	3	100		22	8	7	87	25	21	18	18	100	24	20
31	10	10	100	24	19	6	6	100	22	19	19	19	100	23	20
30	7	7	100	20	18	7	7	100	23	20	15	15	100	22	20
											9	9	100	22	17
29	4	4	100	20	18	8	8	100	22	19					
28	2	2	100		16	7	7	100	20	18	7	7	100	21	16
27	4	4	100	18	17	10	10	100	20	15	6	6	100	20	16
26	1	1	100		16	8	8	100	18	11	6	6	100	19	15
25	1	1	100		21	11	11	100	18	12	6	6	100	17	14
24	4	4	100	15	14	8	8	100	18	13	6	6	100	18	17
23						5	5	100	15	11	4	4	100	16	13
22						5	5	100	15	10	3	3	100		14
21						6	6	100	14	10	2	2	100		13
20						4	4	100	13	7	0				
19											1	1	100		14
18						5	5	100	11	9					
17						0					0				
16						1	1	100		13	0				
15						1	1	100		7	0				
<15						3	3	100		6	0				
						4	4	100		-1	1	1	100		7

Site. - At a height of 209 ft. about $3\frac{1}{2}$ miles south of the centre of Bristol. The land slopes gently down to north and north-west and more steeply to the west. The surrounding country is hilly, mostly grassland and fairly well wooded. About 1 mile to the south Dundrey Hill rises to a height of 600-700 ft.

Table I - continued

CHELTENHAM

Screen Minimum	Autumn (Sept.-Nov.) 237 radiation nights					Winter (Dec.-Feb.) 146 radiation nights					Spring (Mar.-May) 297 radiation nights				
	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground Frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum
°F			%	°F	°F			%	°F	°F			%	°F	°F
43											12	1	8		28
42						2	1	50		29	9	0	0		
41						0					12	0	0		
40						0					13	4	31	27	26
39	5	1	20		28	1	1	100		30	14	3	21		28
38	14	2	14		29	2	2	100		29	19	8	42	29	27
37	12	5	42	29	28	2	2	100		28	12	8	67	29	27
36	3	1	33		30	2	2	100		27	15	14	93	28	24
35	8	8	100	28	28	7	7	100	26	23	15	13	87	27	25
34	8	7	87	28	26	4	4	100	25	24	20	19	95	26	22
33	8	7	87	27	25	0					17	17	100	25	21
32	5	5	100	26	25	8	8	100	25	23	19	19	100	24	19
31	8	8	100	25	21	12	12	100	23	21	8	8	100	24	23
30	6	6	100	23	21	7	7	100	23	21	13	13	100	23	20
29	7	7	100	22	21	13	13	100	21	18	11	11	100	20	16
28	3	3	100		19	17	17	100	21	18	11	11	100	20	16
27	4	4	100	21	19	10	10	100	19	16	4	4	100	19	18
26	2	2	100		19	7	7	100	20	18	3	3	100		15
25	1	1	100		21	11	11	100	18	15	4	4	100	19	13
24	2	2	100		18	5	5	100	17	16	4	4	100	15	14
23	1	1	100		18	2	2	100		13	2	2	100		16
22	1	1	100		16	5	5	100	17	13	1	1	100		15
21						6	6	100	17	14	1	1	100		15
20						5	5	100	16	13	0				
19						3	3	100		12	0				
18						4	4	100	13	12	0				
17						2	2	100		12	0				
16						1	1	100		10	0				
15						3	3	100		6	0				
<15						5	5	100		3	1	1	100		5

Site. - At a height of 214 ft. in a built-up area some $1\frac{1}{4}$ miles from the base of the Cotswolds; the ground slopes down slightly towards the north-east. Light sandy soil. 1

Autumn (Sept.-Nov.) 234 radiation nights						Winter (Dec.-Feb.) 130 radiation nights					Spring (Mar.-May) 288 radiation nights				
Screen Minimum	Frequency	Ground frost Frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum
°F.			%	°F.	°F.			%	°F.	°F.			%	°F.	°F.
40											8	1	13		30
39	13	2	15		29						11	2	18		30
38	12	0	0								10	3	30		27
37	7	3	43		29						12	8	67	28	20
36	13	5	38	29	26						13	10	77	29	27
35	12	6	50	29	28	1	1	100		28	14	11	79	27	25
34	7	4	57	27	25	4	4	100	29	28	18	16	89	28	25
33	11	11	100	28	25	2	2	100		24	17	17	100	27	23
32	8	8	100	28	26	6	6	100	26	23	17	17	100	26	20
31	3	3	100		26	9	9	100	26	21	19	19	100	26	23
30	4	4	100	25	24	11	11	100	25	21	13	13	100	24	20
29	11	11	100	23	18	11	11	100	23	19	19	19	100	24	20
28	3	3	100		24	8	8	100	22	19	14	14	100	22	19
27	5	5	100	20	17	8	8	100	23	19	9	9	100	22	18
26	3	3	100		17	7	7	100	19	15	8	8	100	20	17
25	5	5	100	19	17	11	11	100	21	18	7	7	100	21	18
24	3	3	100		19	7	7	100	20	18	8	8	100	18	16
23	1	1	100		11	12	12	100	19	13	4	4	100	17	15
22						5	5	100	18	15	1	1	100		19
21						1	1	100		14	3	3	100		18
20						7	7	100	18	16	2	2	100		11
19						4	4	100	15	12	1	1	100		19
18						3	3	100		15	1	1	100		13
17						1	1	100		12					
16						1	1	100		9					
15						1	1	100		8					
15						6	6	100		2					

Site. - At a height of 363ft. on an open site at the top of a rise in gently undulating country. Light sandy loam over chalk.

Table I - continued

CULLOMPTON

Screen minimum °F.	Autumn (Sept.-Nov.) 231 radiation nights					Winter (Dec.-Feb.) 138 radiation nights					Spring (Mar.-May) 284 radiation nights				
	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum
42	19	1	5		30										
41	9	2	22		29										
40	9	5	56	29	27						9	1	11		30
											12	3	25		28
39	15	2	13		27	3	1	33		26	19	3	16		23
38	7	1	14		29	0					14	4	29	29	28
37	4	1	25		26	0					12	9	75	28	26
36	11	9	82	29	26	0					11	11	100	29	25
35	11	8	73	29	27	1	1	100		22	12	8	67	28	27
34	8	8	100	28	27	6	6	100	26	22	14	13	93	26	23
33	7	7	100	27	23	7	7	100	26	21	15	15	100	27	25
32	9	9	100	24	21	4	4	100	24	22	21	21	100	25	22
31	11	11	100	24	20	11	11	100	25	20	21	21	100	25	21
30	6	6	100	23	20	13	13	100	23	18	11	11	100	22	15
29	6	6	100	24	22	12	12	100	23	20	9	9	100	22	21
28	7	7	100	21	19	18	18	100	23	16	17	17	100	22	16
27	1	1	100		26	9	9	100	19	15	10	10	100	20	19
26	6	6	100	20	17	9	9	100	18	12	8	8	100	19	14
25	1	1	100		20	5	5	100	16	12	3	3	100		13
24	1	1	100		18	9	9	100	16	12	2	2	100		16
23	2	2	100		16	11	11	100	18	15	4	4	100	16	10
22	1	1	100		16	5	5	100	13	7	4	4	100	17	10
21	1	1	100		16	6	6	100	15	7	1	1	100		18
20	1	1	100		15	3	3	100		16	0				
19						1	1	100		12	1	1	100		15
18						3	3	100		11	0				
17						2	2	100		12	1	1	100		12
16						1	1	100		6					
15						2	2	100		9					
<15						6	6	100		-10					

Site. - At a height of 202 ft. in a sparsely built-up area on a gently sloping valley flank with an east-south-east aspect about 50 ft. above the valley floor. Light sandy soil.

Table I - continued.

PARKEND

Screen Minimum	Autumn (Sept.-Nov.) 233 radiation nights					Winter (Dec.-Feb.) 135 radiation nights					Spring (Mar.-May) 285 radiation nights				
	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum	Frequency	Ground frost frequency	Percentage frequency	Mean grass minimum	Lowest grass minimum
OF			%	OF				%	OF	OF			%	OF	OF
46											5	1	20		29
45											4	0	0		
44	7	2	29		29						5	0	0		
43	14	0	0								7	0	0		
42	11	3	27		26						7	0	0		
41	16	3	19		27						13	2	15		30
40	20	1	5		30						11	3	27		28
39	11	5	45	29	27						10	6	60	29	27
38	7	1	14		29	3	2	67		26	10	5	50	29	27
37	14	8	57	27	25	1	1	100		28	15	9	60	28	27
36	12	5	42	27	24	0					13	11	85	28	25
35	11	6	54	27	24	0					11	9	82	27	22
34	14	11	79	28	24	3	3	100		24	14	13	93	26	22
33	11	8	73	25	19	3	3	100		20	19	17	89	25	18
32	2	2	100		27	4	4	100	23	19	13	12	92	23	19
31	4	4	100	23	19	4	4	100	25	23	16	16	100	24	21
30	11	11	100	25	20	8	8	100	24	20	24	24	100	23	19
29	7	7	100	22	18	10	10	100	24	13	21	21	100	22	14
28	9	9	100	21	17	13	13	100	21	13	15	15	100	21	17
27	4	4	100	20	17	18	18	100	21	17	8	8	100	21	18
26	3	3	100		17	9	9	100	19	16	8	8	100	18	14
25	2	2	100		22	7	7	100	18	15	4	4	100	17	12
24	4	4	100	21	14	10	10	100	17	9	10	10	100	17	9
23	2	2	100		17	7	7	100	18	13	7	7	100	17	12
22	0					8	8	100	16	13	0				
21	1	1	100		20	7	7	100	14	10	2	2	100		15
20						3	3	100		11	1	1	100		17
19						4	4	100	11	8	2	2	100		13
18						1	1	100		14	0				
17						3	3	100		8	0				
16						3	3	100		11	1	1	100		12
15						1	1	100		12					
15						4	4	100		0					

Site. - At a height of 325 ft. on a valley slope which slopes down moderately steeply to the north-east about 200 ft. above the valley floor, in the centre of a forest nursery (10 acres) which is surrounded by an oak with loam soil.